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MARCONI TM6456A

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No. EBM 6456A

for

Dual Trace Unit TM 6456A

plug-in for Oscilloscope TF 2200A

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MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND



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1.1 INTRODUCTION

Dual Trace Unit type TM 6456A forms one of a series of plug-in pre amplifiers for use with Oscilloscope TF 2200A.

This unit provides electronic beam switching which enables two independent signals to be displayed, either on alternate sweeps or chopped at 500 kc/s repetition rate; the chopped mode has transient blanking internally applied during the change-over period to produce a clearly defined display. This unit provides a Y-amplifier pass-band of d.c. to 25 Mc/s with Gaussian roll-off, extending to 35 Mc/s if overshoot is permissible.

Separate switched attenuators and variable gain controls enable the sensitivity of either

channel to be varied independently. Polarity switches in each channel enable either display to be inverted for waveform comparison purposes; this facility, in conjunction with the A + B position of the DISPLAY switch, enables sum and difference measurements to be made. This additional feature of the dual-trace unit applies when each of the input signals produces a display not greater than 5 cm in amplitude. It is recommended that a TV-differential unit may be used should any of the input signals exceed this limit.

Y amplification takes place in two localities in the oscilloscope. All the early stages, phase splitters and beam switching circuits are contained within the plug-in unit. Further amplification is provided by the main Y amplifier mounted inside the oscilloscope itself.

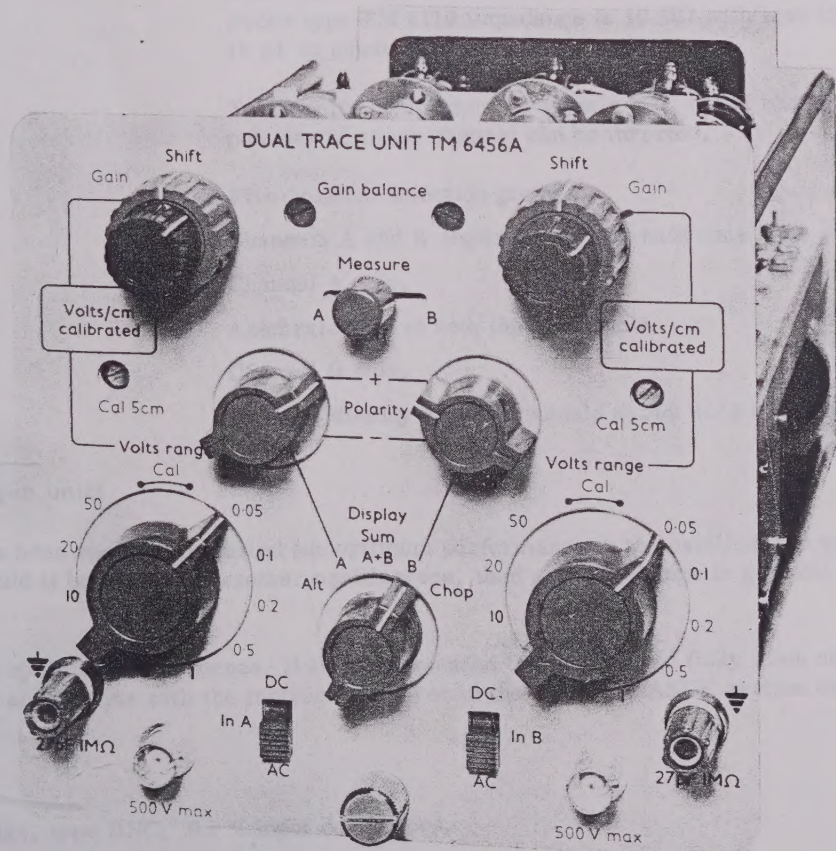


Fig. 1.1 Dual Trace Unit type TM 6456A

1.2 DATA SUMMARY

Overall performance of Oscilloscope TF 2200A with Dual Trace Unit TM 6456A.

BANDWIDTH :

Transient (with Gaussian roll-off
and overshoot less than 1%) : -3 dB at 25 Mc/s.

Wideband (with overshoot) : -3 dB at 35 Mc/s.

RISE TIME :

14 nsec for overshoot of less than 1%.

SENSITIVITY :

Separate attenuators for each channel have ten calibrated steps in 1-2-5 sequence from 50 mV/cm to 50 V/cm. In addition, uncalibrated gain controls provide for continuously variable adjustment over a nominal 2.5:1 on each step of the attenuators. Accuracy of switched attenuator ratios : 2%.

Y SHIFT :

Separate Y shift controls are provided for each channel.

AC/DC SWITCHES :

In the AC positions response is -3 dB at 2 c/s.

PHASE SHIFT :

Time difference between channels is less than 1 nsec.

INPUT IMPEDANCE :

1 M Ω with 30 pF in shunt at all sensitivities. Using Probe type TM 8110 impedance is 10 M Ω with less than 10 pF in shunt.

POLARITY REVERSAL :

To simplify comparison of signals 180° out of phase, the polarity of either channel can be inverted.

DISPLAY SELECTION :

Five-position selection giving :

ALT :

Channels A and B displayed on alternate time base sweeps.

A :

Channel A only.

A + B :

Algebraic sum of both input channels.

B :

Channel B only.

CHOP :

Chopped display of both channels at 500 kc/s switching rate.

Interchangeability of plug-in units

This plug-in unit has been specially adjusted for optimum performance in the oscilloscope with which it is supplied. Should it be used with another oscilloscope, then a small change in general performance may occur.

In order to maintain optimum performance, it is recommended that you should (only when necessary) adjust your plug-in unit in accordance with the instructions given in the MAINTENANCE section of this handbook.

Accessories supplied

Two coaxial free plugs, type BNC; for Y input connectors.

Operation

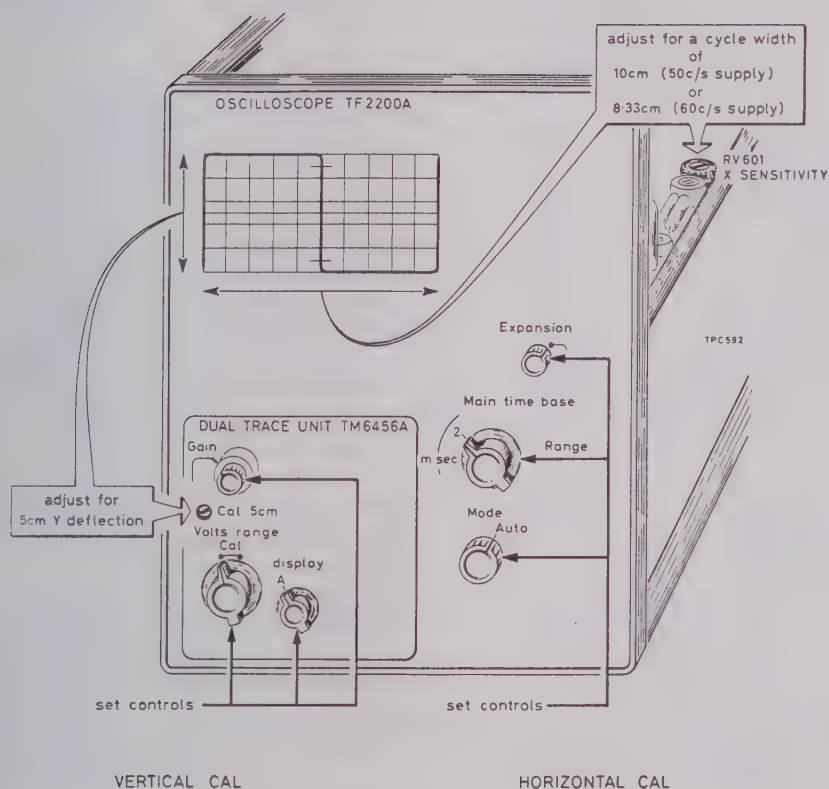


Fig. 2.1 CAL adjustments

2.1 CONTROLS

IN A and IN B

Signals applied to these type BNC coaxial input sockets are controlled by the DISPLAY switch; either a.c. or d.c. coupling may be used; each socket is completely independent of the other, the isolation between them being of the order of 60 dB. The input impedance is 1 M Ω , with a shunt capacitance of 30 pF at all settings of the sensitivity controls; the maximum permissible input is 500 V d.c. or peak a.c.

AC-DC

In the AC position the frequency response is -3 dB at 2 c/s.

DISPLAY

This is a five-position selector giving :-

ALT

Channels A and B displayed on alternate time base sweeps.

A

Channel A only.

A + B

Algebraic sum of both input channels.

B

Channel B only.

CHOP

Chopped display of both channels at 500 kc/s switching rate.

Electronic channel section is employed using gating circuits. Isolation between channels is dependent upon frequency and at 35 Mc/s (the worst condition) is better than 30 dB. If, in the chopped condition, one channel is severely overloaded so that the spot is deflected by several screen diameters, an 'apparent breakthrough' will be observed, even at low frequencies, resulting from the finite rise time of the deflection circuits.

POLARITY To simplify comparison of signals 180° out of phase, the polarity of either channel can be inverted by these switches.

VOLTS RANGE These are independent switched attenuators governing the deflection sensitivities of the two channels. Each switch has ten calibrated steps in 1-2-5 sequence from 0.05 V/cm to 50 V/cm. In addition, the uncalibrated GAIN controls provide continuously variable adjustments from 0.05 V/cm to approximately 125 V/cm for each channel.

CAL position When either one of the VOLTS RANGE switches is set to its CAL positions, a 250 mV trap-ezoidal waveform is displayed, provided the DISPLAY switch is set to the appropriate channel. This should produce a 5 cm p-p display when the associated variable GAIN control is set to its CALIBRATED position. Errors may be corrected by adjustment of the appropriate screwdriver-operated CAL 5 cm control.

CAL 5 cm With the oscilloscope operating from a synchronous 50 c/s supply, one cycle of this CAL waveform should occupy a width of 10 cm when the main time base RANGE control is set to 2 msec with the EXPANSION control set to its CALIBRATED position. The X amplifier sensitivity may be reset, if necessary, by adjusting RV601. On accurate 60 c/s supply mains, one cycle of CAL waveform should occupy a width of 8.33 cm.

GAIN

These separate controls vary the gain of the Y pre-amplifiers over a nominal range of 2.5:1.

Both potentiometers are uncalibrated except for their maximum positions, at which settings the volts/cm calibration of the associated VOLTS RANGE control is correct. (To check or adjust this condition see CAL 5 cm above.)

The settings of the variable GAIN controls have little effect upon the accuracy of VOLTAGE SCALE measurement.

SHIFT

The settings of these controls determine the vertical position of the two traces. Clockwise rotation moves the trace upwards.

MEASURE

This three-position switch enables the VOLTAGE SCALE to be connected to either channel, as desired. When voltage measurement facilities are not required, the VOLTAGE SCALE circuit may be switched out.

GAIN BALANCE

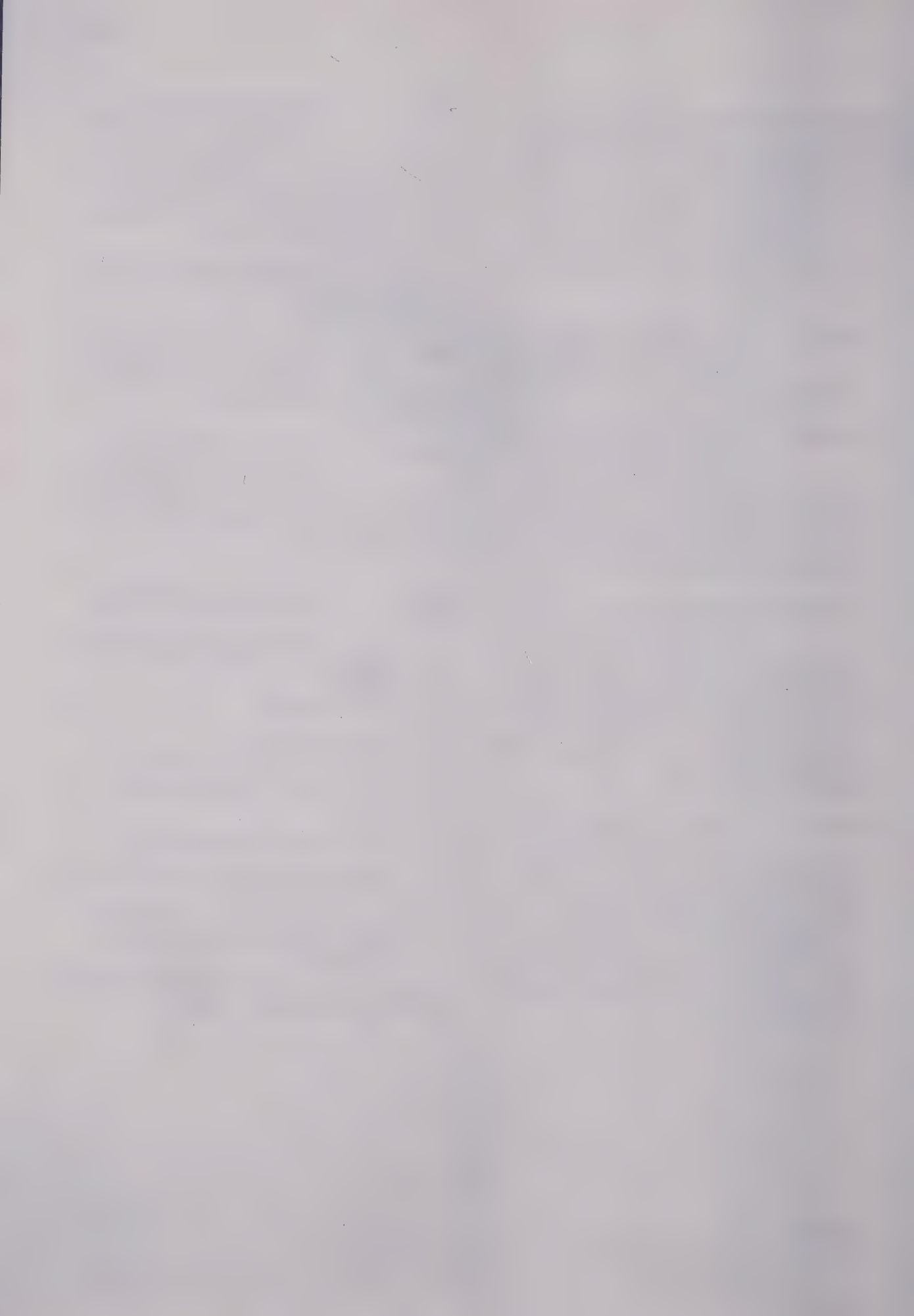
Adjusted so as to minimize Y shift when the gain is varied.

RV7, the left-hand preset, adjusts channel A and RV8, the right-hand preset adjusts channel B.

To adjust these presets :-

- (1) Select input channel A.
- (2) Turn the GAIN control to maximum.
- (3) Adjust the SHIFT control to centre the trace.
- (4) Turn the GAIN control to minimum.
- (5) Adjust the left-hand GAIN BALANCE control to re-centre the trace.
- (6) Repeat steps (2) to (5) until negligible shift occurs in step (4), and step (5) becomes unnecessary.

Channel B is adjusted in an exactly similar manner using the right-hand preset control.



Technical description

It is suggested that the following circuit description be read in conjunction with the block schematic and circuit diagrams included in this handbook.

3.1 INPUT

Two type BNC input sockets are provided, one for each input channel. Each channel has its own input coupling capacitor which may be short circuited by its associated switch. After leaving the AC/DC switches, the two signals are taken direct to separate switched attenuators.

3.2 SWITCH ATTENUATOR

(Circuit diagram Fig. 6.2)

Synopsis

The switch attenuators are sub-assemblies common to all the plug-in units and, for this reason they are considered and described as a separate unit. Mechanical differences exist between the right and the left-hand attenuators used in the dual trace unit, and slight electrical differences exist between the attenuators used in the different plug-in units, but these may be disregarded for the purposes of understanding the circuit. The design is based upon the following considerations :-

- (1) Stray capacitance is reduced to a minimum.
- (2) Unused attenuator elements are shorted to earth.
- (3) Input resistance is $1\text{ M}\Omega$ on all ranges.
- (4) All attenuator sections match into $1\text{ M}\Omega$.

The switch is designed to give the attenuation factor corresponding to each voltage setting detailed below :-

VOLTS RANGE
setting

Input
divided by

0.05	1
0.1	2
0.2	4
0.5	10
1	20
2	40
5	100
10	200
20	400
50	1000

CAL) Input open circuit, attenuators earthed, and CAL signal connected to cathode follower.

Typical performance figures for the switch attenuator, when correctly adjusted, are as follows :-

- $\pm 2\%$ at 50 c/s on all ranges
- $\pm 5\%$ at 30 Mc/s on 1 V range and below
- $\pm 30\%$ at 30 Mc/s on 2 V range and above

To improve the performance of your oscilloscope for high frequency, high range measurements you may use an external attenuator and select a lower switch range.

Circuit analysis

Fig. 6.3 shows the components used in each of the settings of the attenuator switch. The preset capacitors are shown in brackets, and these are based on the values of stray capacitance indicated on the diagram.

0.05 V range

The mechanical design of the switch rotors and contacts keep stray capacitance to a minimum on this range. R2 in parallel with C4 acts as an 'all pass' network, but protects the input cathode follower in the event of severe overloads. Trimmer capacitor C1 adjusts the input capacitance to

be the same as on the 0.1 V range (all the ranges are adjusted with reference to the 0.1 V range). R9 is left in circuit but is short-circuited for reasons of switching simplicity.

0.1 V range

This range is used as a reference for input capacitance adjustment of the ranges. C5 has a tolerance of ± 0.5 pF and C9 is adjusted to make the capacitive pot-down ratio exactly 2:1, so that the input capacitance of the pot-down section is $11 \text{ pF} \pm 0.25 \text{ pF}$. The total input capacitance is therefore 16 pF ; comprising 3 pF (strays), $2.2 \text{ pF} \pm 0.5 \text{ pF}$ (C2) and $11 \text{ pF} \pm 0.25 \text{ pF}$ (pot-down section). The total variation of input capacitance is $\pm 0.75 \text{ pF}$ with an additional $\pm 1 \text{ pF}$ for variation of strays. R3 and R6 are of such values that, in conjunction with R9, they function as a $+2$ attenuator and have an input resistance of $1 \text{ M}\Omega$.

R2 and C4 are switched out of circuit on this, and all subsequent ranges – the pot-down components themselves afford adequate protection.

0.2 V range

Trimmer capacitor C11 enables the capacitive pot-down to be set exactly to 4:1, after which C8 is set to match the input capacitance to that of the 0.1 V range. R4 and R7 are of such values that, in conjunction with R9, they function as a $+4$ attenuator and have an input resistance of $1 \text{ M}\Omega$.

0.5 V range

Trimmer capacitor C12, padded by C13, enables the capacitive pot-down ratio to be set to exactly 10:1, after which C3 is set to match the input capacitance of the 0.1 V range. R5 and R8 are of such values that, in conjunction with R9, they function as a $+10$ attenuator and have an input resistance of $1 \text{ M}\Omega$.

1 V, 2 V, and 5 V ranges

These ranges use the 0.1, 0.2 and 0.5 V sections cascaded with a $+10$ section consisting of C15, C18, C19, C20, R11 and R12 (shunted by R9). Trimmer capacitor C19 enables the cap-

acitive pot-down ratio to be set to exactly 10:1, after which C15 is set to make the input capacitance of the $+10$ section the same as that of the cathode follower valve. Again the section has an input resistance of $1 \text{ M}\Omega$, thus correctly loading the preceding section.

10 V, 20 V, and 50 V ranges

Here the $+10$ section is replaced by a $+100$ section comprising C14, C16, C17, C21 and R10, R13 (shunted by R9). The capacitive pot-down trimmer cannot be connected in the earthy arm as the value would be prohibitively large. Instead, it is connected across the top arm, in series with C17 to reduce its coverage. C14 sets the input capacitance of the $+100$ section to be the same as that of the cathode follower valve and ensures correct loading of the previous section.

Despite every design precaution, the stray inductance associated with capacitor C21 produces a resonance at about 300 Mc/s and, on the top three ranges only, this would have a serious effect on the display of pulses with very fast rise times. Resistor R15, in conjunction with the valve input strays, forms a low-pass filter to counteract this effect; this attenuates a 30 Mc/s signal by about 0.5 dB but greatly improves the shape of fast-pulse displays.

CAL positions

In the CAL positions the input is open-circuited and isolated from the cathode follower. In its place a 0.5 V p-p trapezoidal calibration waveform is connected via R14 and R9 which form a $+2$ section; this produces the desired 250 mV p-p testing waveform at the grid of the amplifier. When the CAL waveform is not required the junction of R14 and C22 is disconnected from R9 and shorted to earth; this ensures no breakthrough to the high impedance grid circuit. In this condition R14 is hunted across the CAL generator output; the loading of $1 \text{ M}\Omega$ has no significant effect upon the CAL waveform (which might be required for the other channel of the dual trace unit) due to the low source impedance of the generator, approximately 330Ω . C22 is included to decouple a small amount of e.h.t. (20 kc/s) breakthrough and renders it invisible on the screen. The rise time of the supply frequency trapezoid is about 30 to 40 μsec .

3.3 DUAL TRACE CIRCUIT

(Circuit diagram Fig. 6.4)

Synopsis

(Block schematic diagram Fig. 6.1)

After leaving the VOLTS RANGE switch attenuator (see Section 3.2) the signal passes via a cathode follower, through the POLARITY +- switch, to one of the grids of a phase splitting pair. The complimentary cathode follower is either earthed or takes its input from the variable voltage across the VOLTAGE SCALE potentiometer. This voltage is then passed through the SHIFT injection network (typically R14, R17 etc.), through the POLARITY +- switch to the other grid of the phase splitting pair.

The outputs from the anodes of the phase splitters are coupled to the grids of the double-triode gating valves. If pins 2 and 7 are held at the same potential, the gating valve acts as a unity-gain amplifier; if pin 7 is more than 6 V negative with respect to pin 2 the valve acts as an open circuit in the signal path. Signals from channel A, channel B, or both, depending on the setting of the DISPLAY switch, will therefore appear across R46 and R53. This signal is fed to the common amplifier where a.c./d.c. compensation is applied. The output from this amplifier is then fed via isolating cathode followers to the output plug.

The gate drive circuit produces voltage levels which are applied to the gating valves according to the setting of the DISPLAY switch. The gating circuit performs the following functions :-

- ALT : Switches channel A and B into circuit alternately, at time base rate.
- A : Selects channel A only.
- A + B : Selects both channels A and B, simultaneously.
- B : Selects channel B only.
- CHOP : Switches channel A and B into circuit alternately, at an unsynchronized rate of 500 kc/s. It also generates blanking pulses during the change-over period; these are fed to the cathode of the c.r.t. via C18 and V107 in the Y amplifier, to produce 'clean' traces.

Circuit analysis

The following circuit analysis is given for the A channel but it applies equally to all the complementary parts of the B channel.

V1, the input cathode follower is driven by the output from the VOLTS RANGE attenuator. This valve operates in an entirely conventional manner and will handle large signal inputs with negligible distortion of the waveform. The 470 Ω resistor and 1 μ F capacitor in the anode circuit are necessary to filter out traces of 20 kc/s e.h.t. ripple on the +100 V line; without this filter, the grid-anode capacitance of the valve passes traces of 20 kc/s ripple to the grid and this would be amplified and displayed. A polarity balance control, RV1, is fitted to enable cancellation of residual unbalance between the grid cathode voltages of the input pair. When RV1 is rotated from end to end of its travel, the junction of R14 and R19 varies with respect to the main potential of the other cathode resistor, R13, by ± 0.7 V.

The SHIFT control works in a similar manner to RV1, producing ± 1 V with respect to the mean potential but this voltage is switched by the NORMAL/INVERT switch to maintain a constant bias on the phase splitter grids regardless of the NORMAL/INVERT switch position.

With the GAIN control, RV5, set to maximum (3 k Ω) the phase splitter stage has a gain of 2, so that 1 V input produces 1 V output at the anodes of both V3 and V4, in antiphase. The gain is reduced by approximately 2.5:1 when the GAIN control is set to minimum.

After phase splitting, the signal is applied to the double-triode gating valves, V7 and V8, whose function is to provide an inertia-free switch. Ideally, this stage should either pass the signal with no attenuation, or completely suppress it. The capacitance between input and output must, therefore, be a very low value to avoid h.f. breakthrough in the 'off' position. Double triodes were chosen in preference to pentodes to avoid the possibility of a.c./d.c. effects due to screen grid heating. In practice, the breakthrough is approximately -30 dB at 30 Mc/s and of a very much lower order as the frequency is reduced.

The gate operates in the following manner :-

If all four grids of V7 and V8 are biased to +31 V and a 0.1 V signal is applied to pins 2, then the cathode (pins 3 and 8) will have 50 mV of signal on them and an output signal of $50 \text{ mV} \times \text{GmR}_L$ will appear at the anodes (pins 6). If, now, pins 7 are made +22 V (-9 V with respect to pins 2) the current that was previously shared equally between the two halves of each valve now flows through the input half of the valves only - the output halves being biased to cut-off. A 0.1 V signal applied to pins 2 produces 0.1 V on the cathodes; since the output halves of both valves are cut off, no amplification takes place and capacitive breakthrough is the only possible source of output.

In the gate stage, the tail current, and consequently the gain of the output halves, can be varied by 1.8:1 by means of preset gain control RV9. R44 and C10 are included so that, in the CHOP position of the DISPLAY switch, the current pulses at anode pin 1 are decoupled to earth and not permitted to 'ring' the +100 V line.

The output signals from V7, V8, V9, and V10 are combined across R46, L9 and R53, L10 to form a mixed push-pull waveform for application to the control grids, pins 2, of V11 and V12. The precise form of this waveform will, of course, depend on the setting of the DISPLAY switch. V11 and V12 have a gain of 2.4 times making the overall gain 3.8 times with the preset gain controls at maximum; preset control RV11 enables the static voltages to be adjusted so that, when both the A and B traces are central, the SUM display is also central.

R62 and R63 form the anode loads of the push-pull stages V11 and V12, and shunt compensation is provided by L11 and L12. R64, R65 and C13 forms a shunt correction network which minimizes the a.c./d.c. (screen heating) effects in the unit.

Gate drive circuit

ALT : V15 is an ECC88, wired as a bistable circuit so that either the 'a' half or the 'b' half can be conducting. To change the bistable state, a positive-going sync pulse of some 3 V amplitude is applied to the cathodes via C17.

A : In the A position of the DISPLAY switch, the grid of V15b (pin 7) is taken to a highly negative (-115 V) line via S6c, thus cutting off V15b and turning on channel A.

B : In the B position of the DISPLAY switch, the grid of V15a (pin 2) is taken to the same negative line via S6d, thus cutting off V15a and turning on channel B.

A + B : Both cathodes are earthed via S6a in the A + B position of the DISPLAY switch; this cuts off both halves of V15 and turns on both channels. At the same time S6a switches in R81 to maintain a constant drain on the +33 V line, thus preventing Zener diode MR1 from taking excessive current.

CHOP : The bistable circuit is modified by S6c and S6d into a conventional cross-coupled multivibrator which runs at 500 kc/s. The common cathodes are not earthed but are allowed to 'cathode follow', thus minimizing the anode loading and also providing a double-frequency signal which is taken via C18 to the blanking amplifier for transient suppression. It is in this mode of operation that diodes V13 and V14 perform a useful function; they flatten off the otherwise tilting tops of the gate drive waveform, thus ensuring minimum tilt on the displayed signals.

The 33 V line is clamped by Zener diode MR1 which is a 1 watt type; it accommodates both component tolerances and the demand variations resulting from different gain settings.

It is strongly recommended that you should become familiar with the principles described in Section 3 - Technical Description - before commencing with the adjustment or replacement of components. The circuit diagrams and component lists show all the electrical components contained in the unit, together with their values and significant ratings.

In case of difficulties, or for general advice on servicing your instrument, do not hesitate to write or telephone our Service Department or nearest representative. Always mention the type number and serial number of your instrument and its plug-in unit. (For addresses and telephone numbers see the rear of this handbook.)

4.1 WORKING VOLTAGES

The static voltages appropriate to certain parts of the dual trace unit are given in Fig. 6.4. All measurements were taken with the oscilloscope functioning normally, by means of a 20,000 Ω/V meter, e.g., Avometer Model 8. Unless otherwise stated, all voltages are measured with respect to chassis.

On individual units and oscilloscopes, some differences in voltage readings may be expected due to normal variations of valve performance and the tolerance of associated components. Before making any measurements, adjust the supply voltage plugs to agree as closely as possible with the actual supply voltage.

4.2 WIRING COLOUR CODE

The various supply leads in the oscilloscope are colour coded to assist rapid identification during manufacture and subsequent servicing. Details of this colour code are given in the Maintenance section of the oscilloscope handbook. The colour coded leads are continued, through the 24-way connectors, into the plug-in

units. All the pins of these connectors are numbered and may be identified by reference to the circuit diagram.

4.3 REPLACEMENT OF VALVES AND SEMICONDUCTORS

Valves

It is recommended that faulty valves should be replaced by the type originally supplied in the unit. In general, most valves may be replaced without special selection or aging, although in certain cases replacement may necessitate some readjustment of associated preset components as described in Section 4.4.

Semiconductors

Replacement of the Zener diodes in the dual trace unit will not necessitate any adjustment of preset controls provided they are of identical type number to those originally fitted.

Be very careful to avoid overheating the replacement diode - each joint being made as rapidly as possible. The use of a thermal shunt between the Zener diode and the soldering iron is strongly recommended.

4.4 ADJUSTMENT OF PRESETS

If your dual trace unit was supplied at the same time as your oscilloscope, it will have been specially adjusted to achieve the best possible performance with your particular instrument, and it is unlikely that future adjustments will be required. Units which are supplied separately may need slight adjustment if optimum pulse performance is required, and this is described in the next section - Adjustment procedure.

Following valve replacement it is possible that certain readjustments will be necessary as listed below :-

Component replaced	Adjustment required
V1	RV1
V2	RV2
V3	RV7)
V4	RV7)
V5	RV8)
V6	RV8)
V7	None
V8	None
V9	None
V10	None
V11	RV11
V12	RV11
V13	None
V14	None
V15	RV12
MRI	None

Front
panel
controls

Adjustment procedure

RV1, POLARITY BALANCE : This preset control is located at the left-hand side of the unit, near the front of the chassis. Select input channel A, set the associated VARIABLE GAIN control to maximum, and adjust the SHIFT control for a central trace. Reverse the POLARITY switch and then adjust RV1 so as to halve the error - i.e., to bring the trace back towards the centre of the screen by half the required amount. (The BEAM LOCATE button may have to be used, in order to make the trace visible.) Restore the POLARITY switch to its original setting, adjust the SHIFT control to obtain a central trace, and repeat the above procedure several times. When RV1 is correctly adjusted, no shift should result when the POLARITY switch is reversed.

RV2, POLARITY BALANCE : RV2 is the counterpart of RV1, in input channel B. It is located at the right-hand side of the unit, in a similar position to RV1. Adjustment can be effected by inserting a long screwdriver through the hole provided in the side of the time base unit. Alternatively, the dual trace unit may be withdrawn from the oscilloscope and operated by means of Extension Cable type TM 6943. Select input channel B, and adjust RV2 by using a similar procedure to that already described for RV1.

RV7, GAIN BALANCE : This preset control is mounted, together with RV8 and the VARIABLE GAIN potentiometer, on a bracket in the middle

of the chassis. RV7 is the left-hand preset, and is adjusted from the front panel. Select input channel A and turn the channel A VARIABLE GAIN control to maximum. †Adjust the SHIFT control to centre the trace, turn the VARIABLE GAIN control to minimum and then adjust RV7 to re-centre the trace. Repeat from † as necessary.

RV8, GAIN BALANCE : RV8 is mounted on the right of RV7 and performs an identical function for channel B. To adjust RV8, select channel B and use a similar procedure to that described for RV7.

RV11, FUNCTION BALANCE : RV11 is mounted on the rear edge of the chassis at the right-hand side of the dual trace unit. Adjustment can be effected by turning the entire oscilloscope upside down, and inserting a screwdriver through the hole provided in the front edge of the main Y amplifier chassis. Alternatively, the dual trace unit may be withdrawn from the oscilloscope and operated by means of Extension Cable type TM 6943. To adjust RV11 proceed as follows :-

- (1) Set both VARIABLE GAIN controls to maximum.
- (2) Select channel A and adjust the appropriate SHIFT control for a central trace.
- (3) Select channel B and adjust the appropriate SHIFT control for a central trace.
- (4) Select A + B and note the position of the trace. (If necessary, press the BEAM LOCATE button.)
- (5) Adjust RV11 to introduce even greater shift away from the centre line of the graticule. (If the BEAM LOCATE button is not being used, adjust RV11 to double the distance between the trace and the centre of the screen.)
- (6) Repeat steps (2), (3), (4), and (5), until there is no shift away from the centre line in step (4).

RV12, BISTABLE BALANCE : RV12 is mounted on the rear edge of the chassis at the left-hand side of the dual trace unit. Adjustment can be effected by turning the entire oscilloscope upside down, and inserting a screwdriver through the hole provided in the front edge of the main Y amp-

lifier chassis. Alternatively, the dual trace unit may be withdrawn from the oscilloscope and operated by means of Extension Cable type TM 6943. To adjust RV12, set the DISPLAY switch to ALT, and turn the main time base RANGE switch to its fastest range. Vary RV12 and note the settings where one or other of the two traces disappear; adjust RV12 to a mid-position between these two settings, so that both traces are visible.

Inductors

It is unlikely that valve replacement will necessitate the readjustment of any of the inductors. If it is suspected that the adjustments have been altered, the cores may be reset as follows :-

With the oscilloscope switched to TRANSIENT, apply a flat-topped pulse waveform having a rise-time of 3 nsec (or better) to the channel A input socket. Adjust the Y SHIFT control so that the flat top of the waveform is at the centre of the screen, and set the VARIABLE GAIN control to maximum. Having first ascertained that the cores of L1 and L2 are mechanically symmetrical, adjust

both inductors by equal amounts, for zero overshoot on the display. If L9, L10, and L11, L12, are badly out of adjustment it will not be possible to eliminate the overshoot with L1 and L2. L9 and L10 followed by L11 and L12 should, therefore, be adjusted equally for zero overshoot, and the three sets of inductors adjusted in sequence several times to obtain the best response without overshoot.

Having adjusted channel A for best pulse response, turn the DISPLAY switch to channel B, set the channel B VARIABLE GAIN control to maximum, and apply the pulse waveform to the B input socket. Adjust the Y SHIFT control so that the flat top of the waveform is at the centre of the screen, then adjust L3 and L4 for zero overshoot on the display. All the other inductors are common to channel A and no further adjustment should be required.

Apply a sweep signal and check that the overall performance of the oscilloscope meets the Data Summary figure for bandwidth, using either input channel.

Component lists

INTRODUCTION

Components on Switch Attenuator type TM 6569 are listed before those of the remainder of the unit.

Abbreviations :

SIC : Value selected in calibration; nominal value shown

TE : Total excursion (of tolerance)

Circuit reference	Description	Stock list reference	Circuit reference	Description	Stock list reference
SWITCH ATTENUATOR			C17	6.8pF ± ½pF 750VDC	33—TM6569&/1
			C18	3.3pF ± ½pF 750VDC	32—TM6569&/1
Resistors			C19	5 – 25pF Trimmer	40—TM6569&/1
			C20	8.2pF ± ½pF 750VDC	34—TM6569&/1
R1	1MΩ ± 1% ¼W	15—TM6569&/1	C21	300pF ± 2% 125V	37—TM6569&/1
R2	220kΩ ± 10% ½W	24—TM6569&/1	C22	100pF ± 2% 750V	41—TM6569
R3	500kΩ ± 1% ¼W	19—TM6569&/1			
R4	759kΩ ± 1% ¼W	20—TM6569&/1	Switches		
R5	900kΩ ± 1% ¼W	25—TM6569&/1			
R6	1MΩ ± 1% ¼W	23—TM6569&/1			
R7	333kΩ ± 1% ¼W	18—TM6569&/1			
R8	111kΩ ± 1% ¼W	17—TM6569&/1	S1a	6 sec. 12 Pos.	1—TM6569 9—TM6569/1
R9	1MΩ ± 1% ¼W	23—TM6569&/1	S1b		
R10	990kΩ ± 1% ¼W	22—TM6569&/1	S1c		
R11	900kΩ ± 1% ¼W	21—TM6569&/1	S1d		
R12	111kΩ ± 1% ¼W	17—TM6569&/1	S1e		
R13	10.1kΩ ± 1% ¼W	16—TM6569&/1	S1f		
R14	1MΩ ± 1% ¼W	23—TM6569&/1	S1g		
R15	330Ω ± 10% ¼W	26—TM6569&/1	S1j		
R16	22Ω ± 10% 1/10W	28—TM6569&/1	S1k		
			S1l		
			S1m		
Capacitors					
C1	2 – 7pF Trimmer	39—TM6569&/1			
C2	2.2pF ± ½pF 750VDC	31—TM6569&/1			
C3	2 – 7pF Trimmer	39—TM6569&/1			
C4	.01μF ± 20% 400VDC	38—TM6569&/1			
C5	22pF ± 5% 750VDC	35—TM6569&/1			
C6	8.2pF ± ½pF 750VDC	34—TM6569&/1			
C7	8.2pF ± ½pF 750VDC	34—TM6569&/1			
C8	2 – 7pF Trimmer	39—TM6569&/1			
C9	2 – 7pF Trimmer	39—TM6569&/1			
C10	2.2pF ± ½pF 750VDC	31—TM6569&/1			
C11	2 – 7pF Trimmer	39—TM6569&/1			
C12	5 – 25pF Trimmer	40—TM6569&/1			
C13	39pF ± 5% 750VDC	36—TM6569&/1			
C14	2 – 7pF Trimmer	39—TM6569&/1			
C15	2 – 7pF Trimmer	39—TM6569&/1			
C16	2 – 7pF Trimmer	39—TM6569&/1			

Circuit reference	Description	Stock list reference	Circuit reference	Description	Stock list reference
DUAL TRACE UNIT			R37	$330\Omega \pm 1\% \frac{1}{4}W$	28-TM6456A
Resistors			R38	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R1	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R39	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R2	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R40	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R3	$220\Omega \pm 10\% 0.1W$	52-TM6456A	R41	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R4	$22\Omega \pm 10\% 0.1W$	53-TM6456A	R42	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R5	$22\Omega \pm 10\% 0.1W$	53-TM6456A	R43	$3.3k\Omega \pm 7\% TE \frac{1}{4}W$	34-TM6456A
R6	$220\Omega \pm 10\% 0.1W$	52-TM6456A	R44	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A
R7	$100\Omega \pm 10\% 0.1W$	25-TM6456A	R45	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A
R8	$100\Omega \pm 10\% 0.1W$	25-TM6456A	R46	$160\Omega \pm 1\% \frac{1}{4}W$	26-TM6456A
R9	$15k\Omega \pm 5\% 2W$	43-TM6456A	R47	$2.2k\Omega \pm 5\% 1\frac{1}{2}W$	31-TM6456A
R10	$15k\Omega \pm 5\% 2W$	43-TM6456A	R48	$2.2k\Omega \pm 5\% 1\frac{1}{2}W$	31-TM6456A
R11	$15k\Omega \pm 5\% 2W$	43-TM6456A	R49	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A
R12	$15k\Omega \pm 5\% 2W$	43-TM6456A	R50	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A
R13	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R51	$2.2k\Omega \pm 5\% 1\frac{1}{2}W$	31-TM6456A
R14	$22k\Omega \pm 10\% \frac{1}{4}W$	45-TM6456A	R52	$2.2k\Omega \pm 5\% 1\frac{1}{2}W$	31-TM6456A
R15	$22k\Omega \pm 10\% \frac{1}{4}W$	45-TM6456A	R53	$160\Omega \pm 1\% \frac{1}{4}W$	26-TM6456A
R16	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R54	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A
R17	$3.3M\Omega \pm 10\% \frac{1}{4}W$	35-TM6456A	R55	$8.2k\Omega \pm 5\% 2W$	39-TM6456A
R18	$3.3M\Omega \pm 10\% \frac{1}{4}W$	35-TM6456A	R56	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A
R19	$4.7M\Omega \pm 10\% \frac{1}{4}W$	50-TM6456A	R57	$33k\Omega \pm 10\% \frac{1}{4}W$	42-TM6456A
R20	$4.7M\Omega \pm 10\% \frac{1}{4}W$	50-TM6456A	R58	$2.2k\Omega \pm 10\% \frac{1}{4}W$	32-TM6456A
R21	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R59	$22k\Omega \pm 10\% \frac{1}{4}W$	45-TM6456A
R22	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R60	$820\Omega \pm 5\% 6W$	29-TM6456A
R23	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R61	$15k\Omega \pm 10\% \frac{1}{4}W$	44-TM6456A
R24	$22\Omega \pm 10\% \frac{1}{4}W$	23-TM6456A	R62	$180\Omega \pm 1\% \frac{1}{4}W$	27-TM6456A
R25	$5.6k\Omega \pm 5\% 4\frac{1}{2}W$	38-TM6456A	R63	$180\Omega \pm 1\% \frac{1}{4}W$	27-TM6456A
R26	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R64	$2.7k\Omega \pm 7\% TE \frac{3}{8}W$	33-TM6456A
R27	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R65	$2.7k\Omega \pm 7\% TE \frac{3}{8}W$	33-TM6456A
R28	$150k\Omega \pm 10\% \frac{1}{4}W$	48-TM6456A	R66	$1k\Omega \pm 3\% TE \frac{3}{8}W$	30-TM6456A
R29	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R67	$1k\Omega \pm 3\% TE \frac{3}{8}W$	30-TM6456A
R30	$5.6k\Omega \pm 5\% 4\frac{1}{2}W$	38-TM6456A	R68	$68k\Omega \pm 10\% \frac{1}{4}W$	47-TM6456A
R31	$10\Omega \pm 10\% \frac{1}{4}W$	22-TM6456A	R69	$27k\Omega \pm 10\% \frac{1}{4}W$	46-TM6456A
R32	$8.2k\Omega \pm 5\% 1W$	40-TM6456A	R70	Not used	
R33	$8.2k\Omega \pm 5\% 1W$	40-TM6456A	R71	$47\Omega \pm 10\% \frac{1}{4}W$	24-TM6456A
R34	$330\Omega \pm 1\% \frac{1}{4}W$	28-TM6456A	R72	$68k\Omega \pm 10\% \frac{1}{4}W$	47-TM6456A
R35	$330\Omega \pm 1\% \frac{1}{4}W$	28-TM6456A	R73	$27k\Omega \pm 10\% \frac{1}{4}W$	46-TM6456A
R36	$330\Omega \pm 1\% \frac{1}{4}W$	28-TM6456A	R74	$1k\Omega \pm 3\% TE \frac{3}{8}W$	30-TM6456A
			R75	$1k\Omega \pm 3\% TE \frac{3}{8}W$	30-TM6456A
			R76	$10k\Omega \pm 10\% \frac{1}{4}W$	51-TM6456A

<i>Circuit reference</i>	<i>Description</i>	<i>Stock list reference</i>	<i>Circuit reference</i>	<i>Description</i>	<i>Stock list reference</i>
R77	10k Ω $\pm$ 10% $\frac{1}{4}$ W	51-TM6456A	Capacitors		
R78	2.2k Ω $\pm$ 10% $\frac{1}{4}$ W	32-TM6456A			
R79	22k Ω $\pm$ 10% $\frac{1}{4}$ W	45-TM6456A	C1	.1 μ F $\pm$ 20% 500V	70-TM6456A
R80	15k Ω $\pm$ 10% $\frac{1}{4}$ W	44-TM6456A	C2	.1 μ F $\pm$ 20% 500V	70-TM6456A
R81	3.3k Ω $\pm$ 10% $\frac{1}{4}$ W	36-TM6456A	C3	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R82	3.9k Ω $\pm$ 5% 2W	37-TM6456A			
R83	390k Ω $\pm$ 10% $\frac{1}{4}$ W	49-TM6456A	C4	.1 μ F $\begin{smallmatrix} +50\% \\ -20\% \end{smallmatrix}$ 450V	73-TM6456A
R84	2.2k Ω $\pm$ 5% $\frac{1}{2}$ W	31-TM6456A			
R85	150k Ω $\pm$ 10% $\frac{1}{4}$ W	48-TM6456A	C5	.1 μ F $\begin{smallmatrix} +50\% \\ -20\% \end{smallmatrix}$ 450V	73-TM6456A
R86	10 Ω $\pm$ 10% $\frac{1}{4}$ W	22-TM6456A	C6	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R87	10 Ω $\pm$ 10% $\frac{1}{4}$ W	22-TM6456A			
R88	470 Ω $\pm$ 10% $\frac{1}{4}$ W	54-TM6456A	C7	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R89	470 Ω $\pm$ 10% $\frac{1}{4}$ W	54-TM6456A			
R90	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A	C8	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R91	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A			
R92	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A	C9	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R93	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A			
R94	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A	C10	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R95	22 Ω $\pm$ 10% $\frac{1}{4}$ W	23-TM6456A			
	selected from		C11	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R96	27k Ω $\pm$ 10% 0.1W	55A TM6456A			
R97	33k Ω $\pm$ 10% 0.1W	55B TM6456A	C12	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 350V	69-TM6456A
R98	47k Ω $\pm$ 10% 0.1W	55C TM6456A			
R99			C13	400 μ F $\begin{smallmatrix} +100\% \\ -20\% \end{smallmatrix}$ 6V DC	71-TM6456A
Resistors Variable			C14	Not used	
			C15	22pF $\pm$ 5% 750V	67-TM6456A
RV1	1M Ω $\pm$ 20% 1W	61-TM6456A	C16	22pF $\pm$ 5% 750V	67-TM6456A
RV2	1M Ω $\pm$ 20% 1W	61-TM6456A	C17	.001 μ F $\pm$ 10% 500V	68-TM6456A
RV3	1M Ω $\pm$ 20% $\frac{1}{2}$ W	57-TM6456A	C18	.001 μ F $\pm$ 10% 500V	68-TM6456A
RV4	1M Ω $\pm$ 20% $\frac{1}{2}$ W	57-TM6456A			
RV5	3k Ω $\pm$ 20% $\frac{1}{4}$ W	58-TM6456A	C19	.01 μ F $\begin{smallmatrix} +80\% \\ -20\% \end{smallmatrix}$ 500V	69-TM6456A
RV6	3k Ω $\pm$ 20% $\frac{1}{4}$ W	58-TM6456A			
RV7	2k Ω $\pm$ 20% $\frac{1}{4}$ W	59-TM6456A			
RV8	2k Ω $\pm$ 20% $\frac{1}{4}$ W	59-TM6456A			
RV9	3k Ω $\pm$ 10% 2W	60-TM6456A			
RV10	3k Ω $\pm$ 10% 2W	60-TM6456A			
RV11	50k Ω $\pm$ 20% 1W	63-TM6456A			
RV12	10k Ω $\pm$ 20% 1W	62-TM6456A			

Circuit reference	Description	Stock list reference	Circuit reference	Description	Stock list reference
Inductors			Switches		
L1		86-TM6456A	S1	S.P. M/B (Slide)	91-TM6456A
L2		86-TM6456A	S2	S.P. M/B (Slide)	92-TM6456A
L3		86-TM6456A	S3	3 Pos. (Lever)	90-TM6456A
L4		86-TM6456A	S4A {	1 sec. 2 Pos.	87-TM6456A
L5	Not used		S4B }		87-TM6456A
L6	Not used		S5A {	1 sec. 2 Pos.	88-TM6456A
L7	Not used		S5B }		88-TM6456A
L8	Not used		S6A {	2 sec. 5 Pos.	89-TM6456A
L9		137-TM6456A	S6B }		89-TM6456A
L10		137-TM6456A	S6C }		89-TM6456A
L11		137-TM6456A	S6D }		89-TM6456A
L12		137-TM6456A			
Valves			Sockets		
			SK1	Co-axial BNC	93-TM6456A
			SK2	Co-axial BNC	93-TM6456A
			Plugs		
V1A {	E88CC	119-TM6456A			
V1B }		119-TM6456A			
V2A {		119-TM6456A	PLA	24 Way	94-TM6456A
V2B }		119-TM6456A			
V3	6 BW 7	121-TM6456A	Rectifiers & Diodes		
V4	6 BW 7	121-TM6456A			
V5	6 BW 7	121-TM6456A	MR1 $\pm$ 33V 5%		82-TM6456A
V6	6 BW 7	121-TM6456A	MR2 $\pm$ 100V 5% 8W		81-TM6456A
V7	ECC88	120-TM6456A	Miscellaneous		
V8	ECC88	120-TM6456A			
V9	ECC88	120-TM6456A			
V10	ECC88	120-TM6456A	X1	Ferrite Bead	97-TM6456A
V11	E81OF	122-TM6456A	to		
V12	E81OF	122-TM6456A	X14	Mullard FX1065/2B	97-TM6456A
V13	EA 76	123-TM6456A			
V14	EA 76	123-TM6456A			
V15A {	ECC88	120-TM6456A			
V15B }		120-TM6456A			

Circuit diagrams

CIRCUIT NOTES

1. COMPONENT VALUES

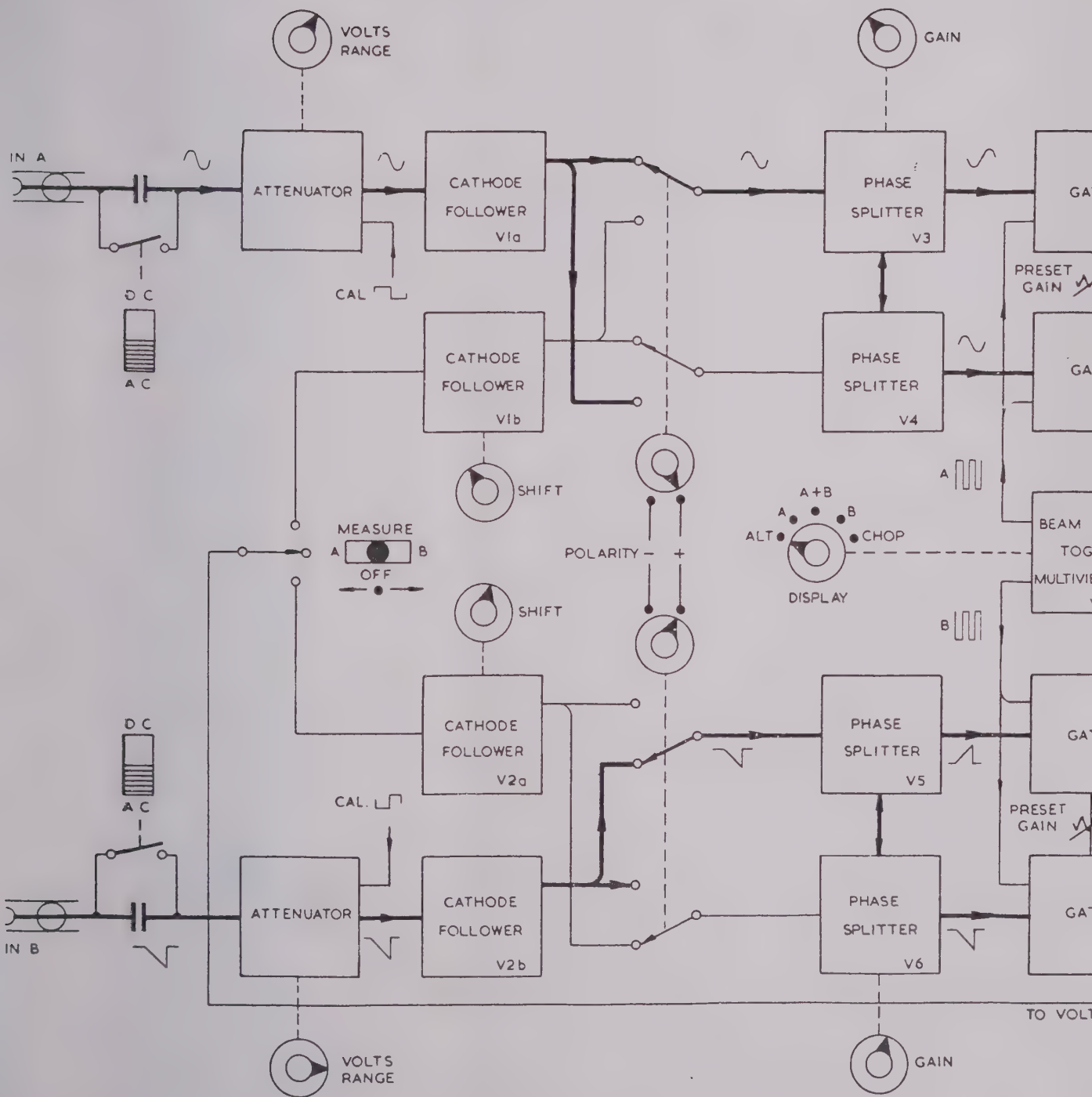
Resistors : No suffix = ohms, k = kilohms, M = megohms.

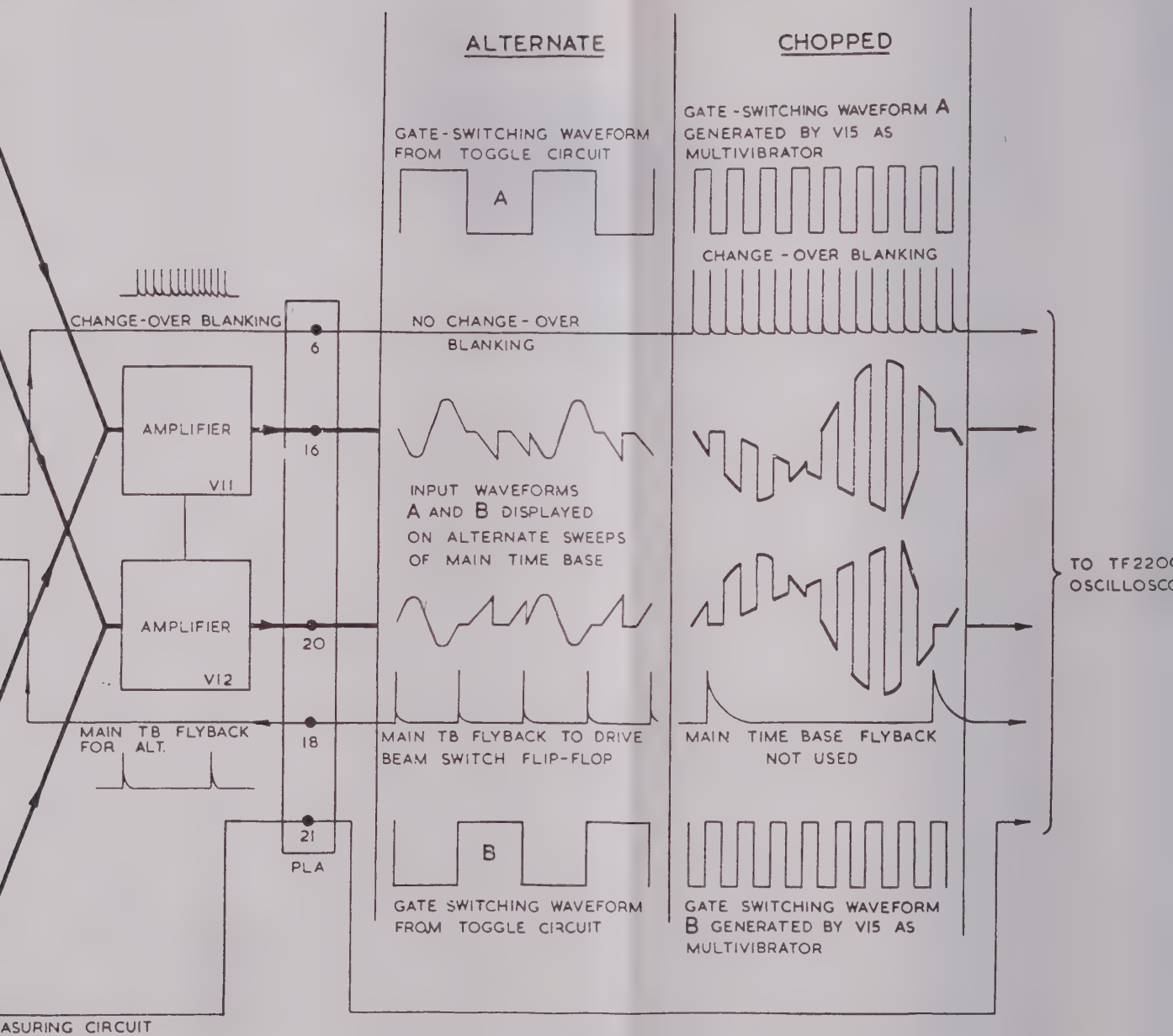
Capacitors : No suffix = microfarads, p = picofarads.

SIC : Value selected in calibration; nominal value shown.

2. SWITCHES

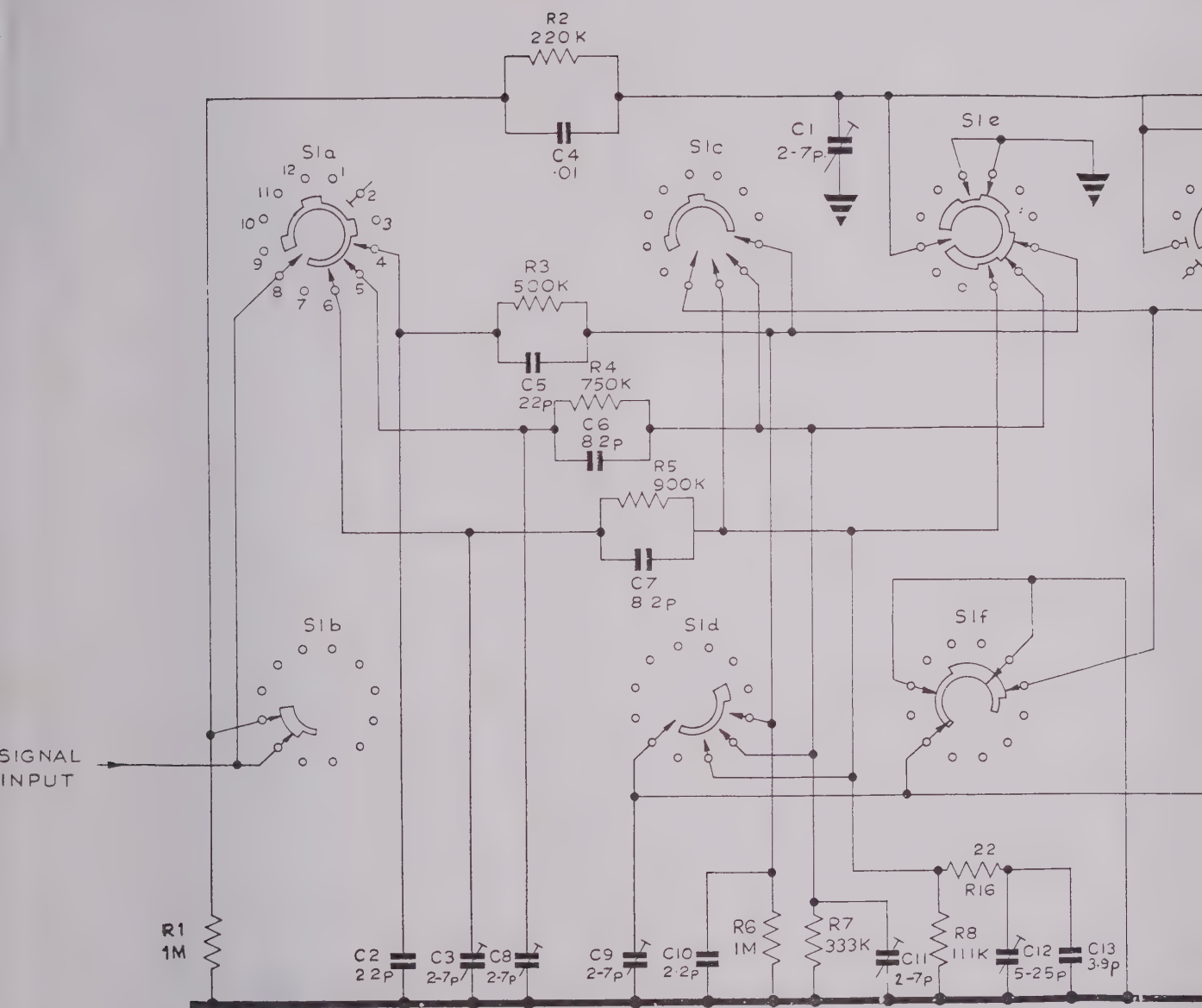
Sections are drawn as viewed from knob end with switch in fully counter-clockwise position.





BLOCK SCHEMATIC

Fig 6.1



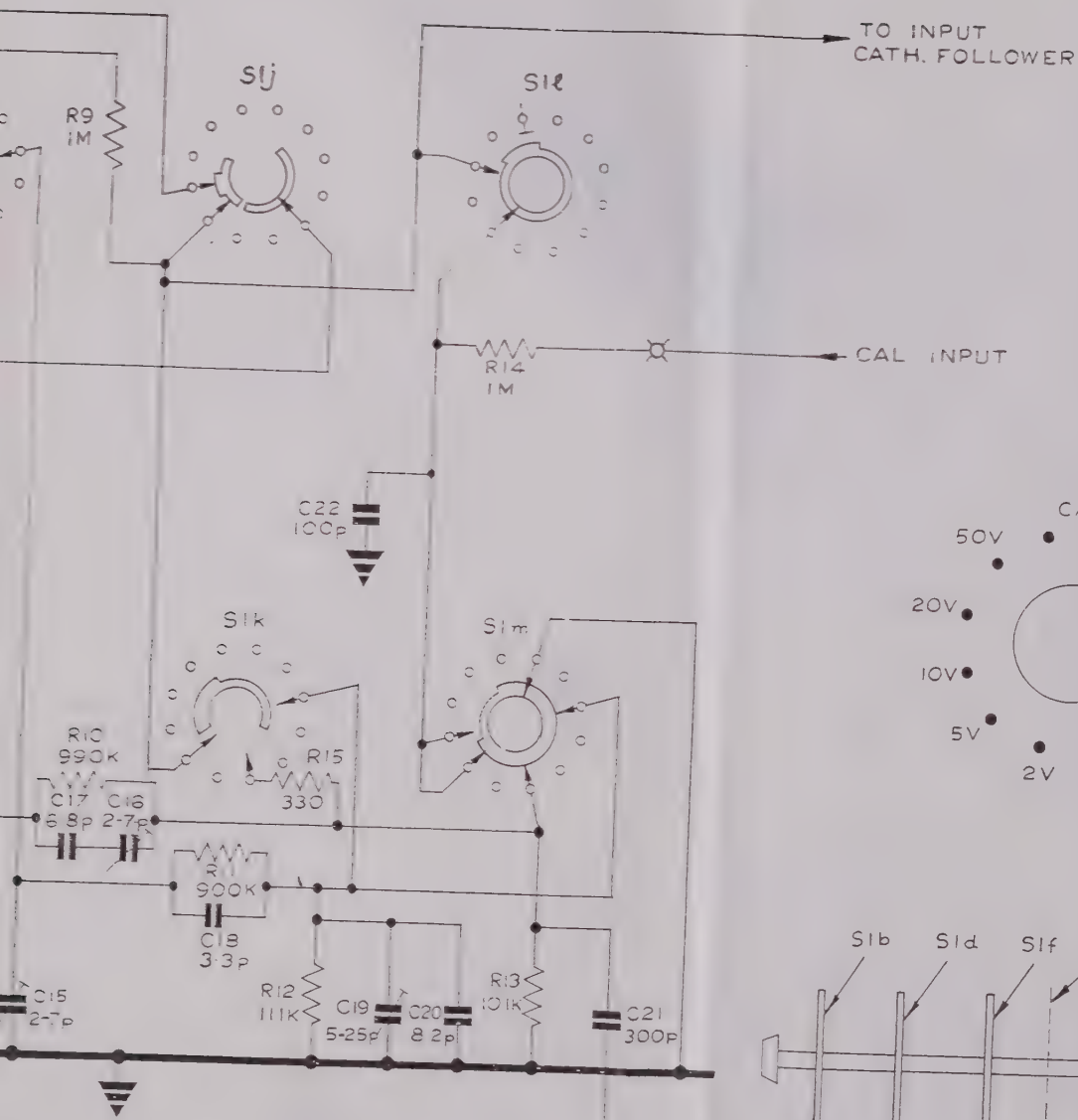
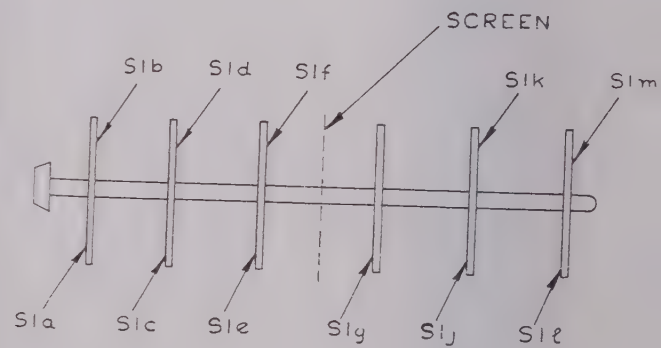
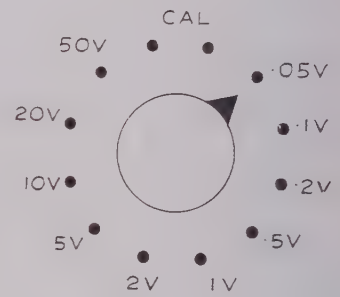
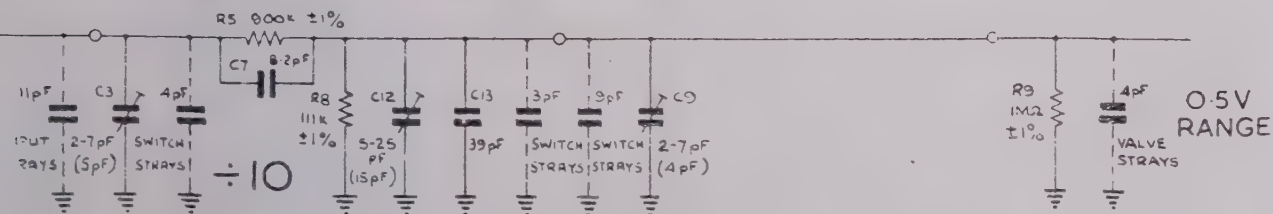
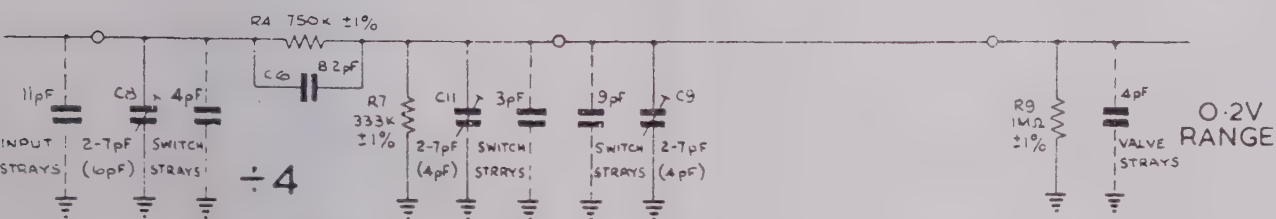
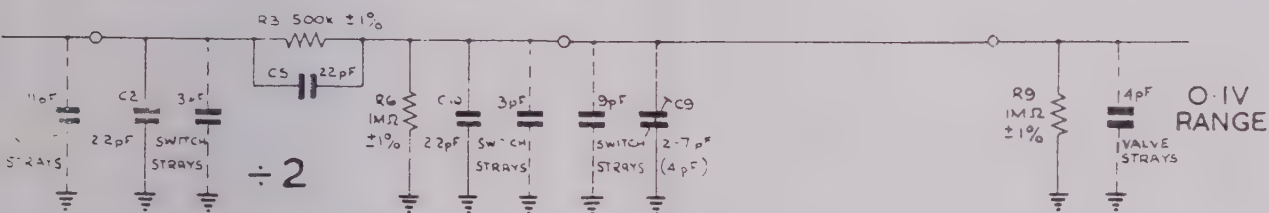
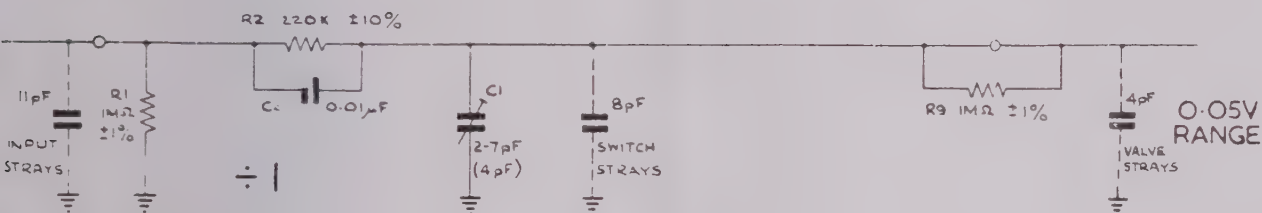
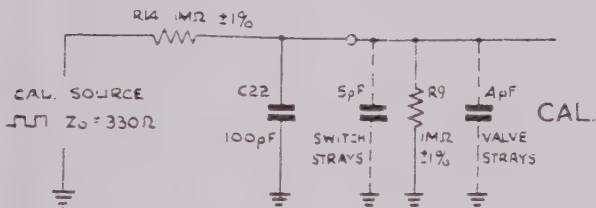
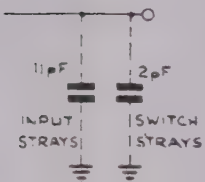
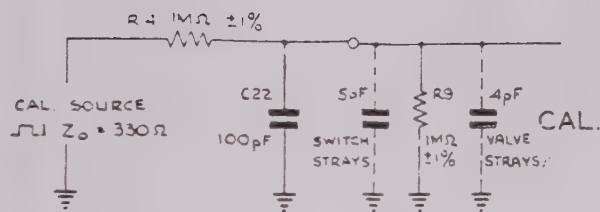
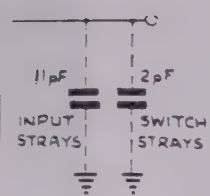


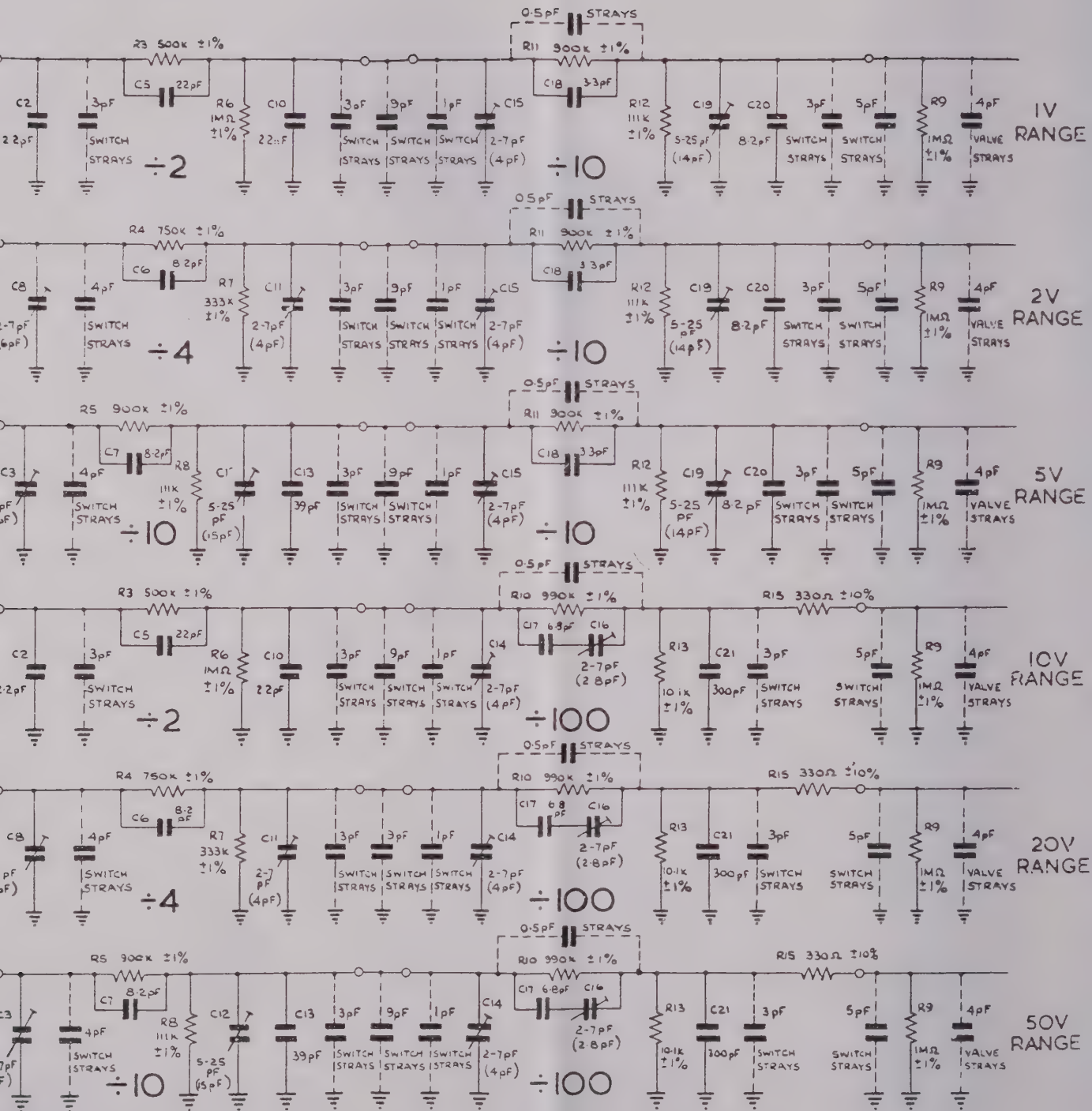
Fig 6 4



SWITCH ATTENUATOR
CIRCUIT

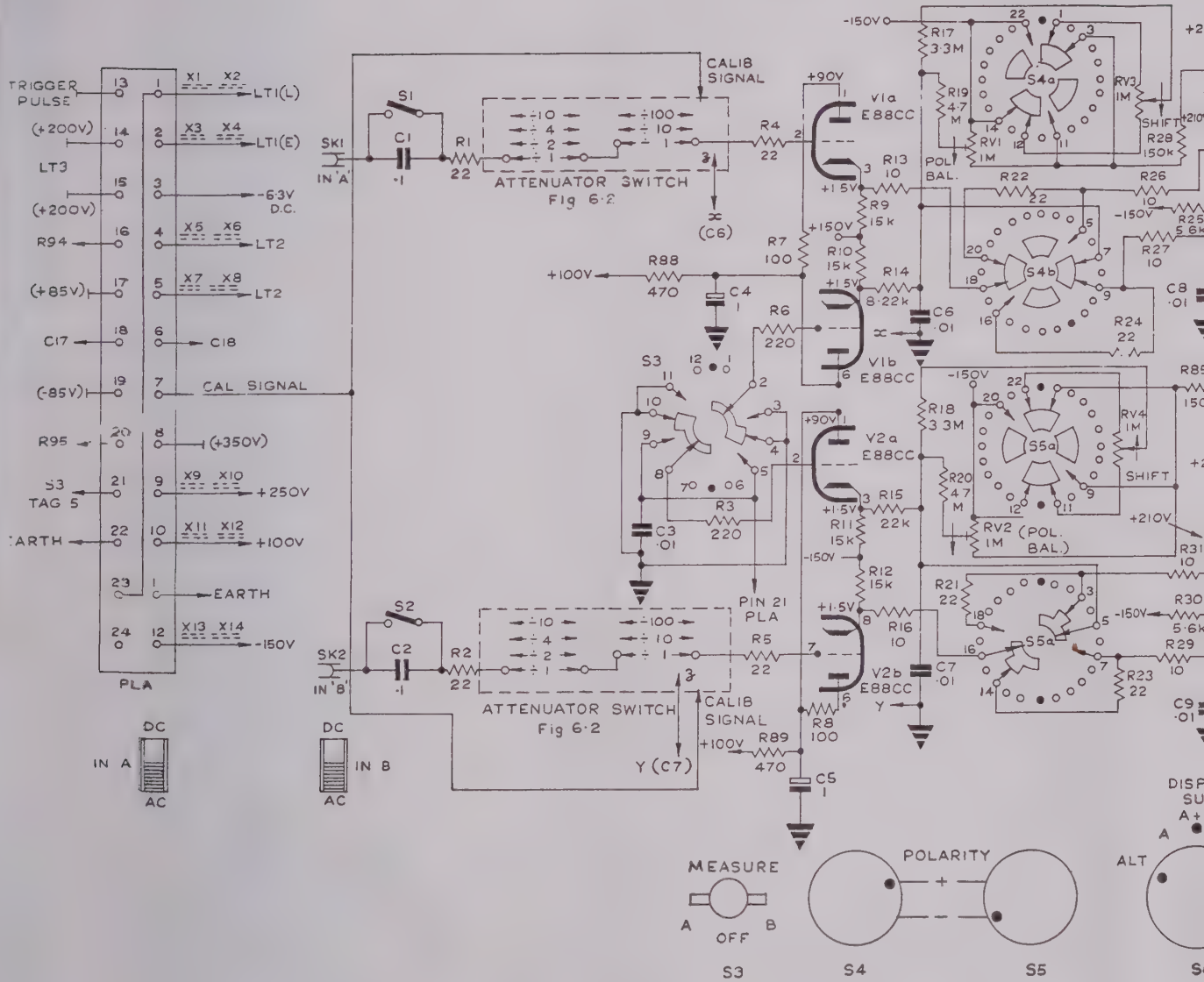
Fig 6.2

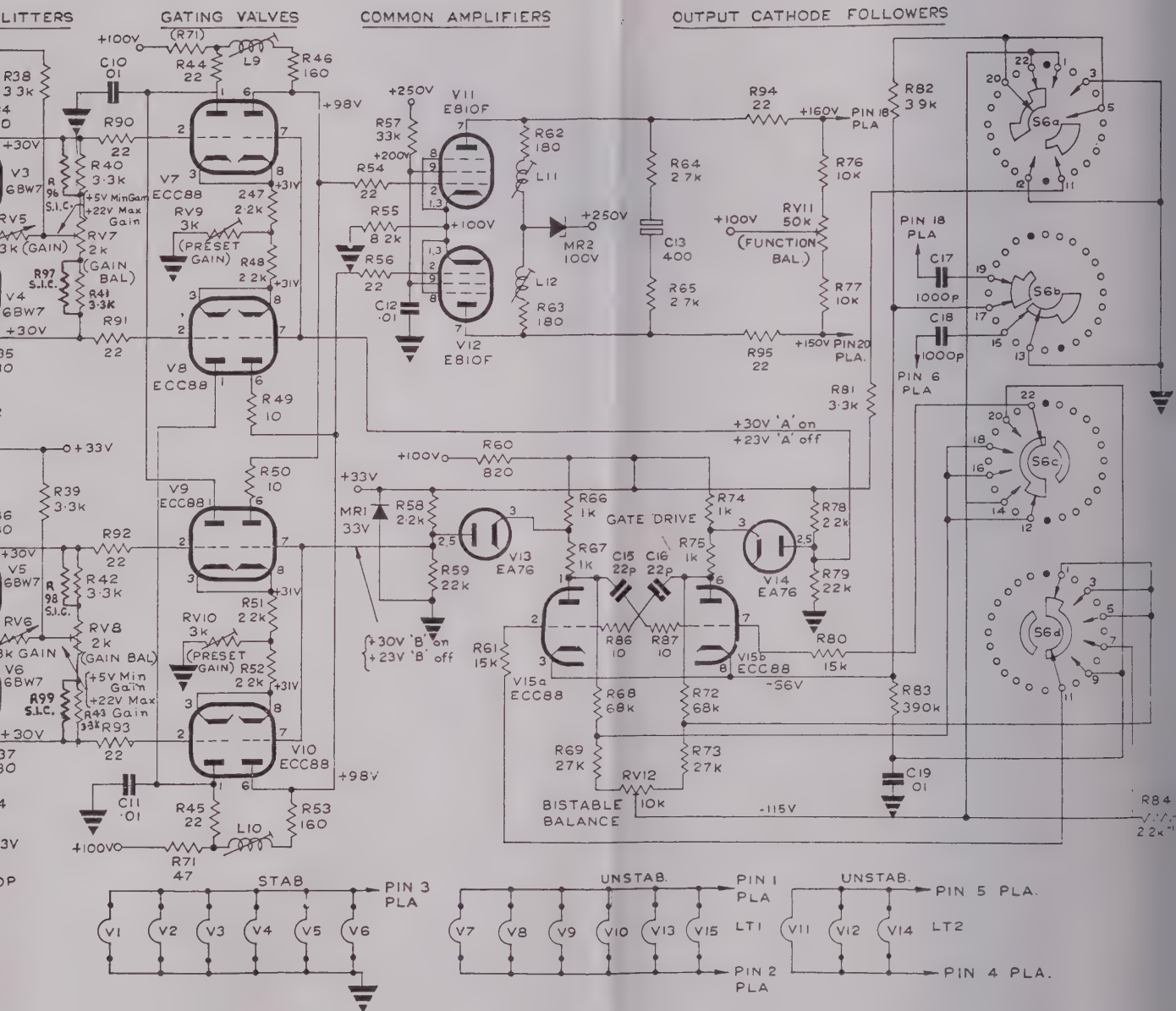




ANALYSIS OF SWITCH ATTENUATOR RANGES Fig 6.3

INPUT CATHODE FOLLOWERS

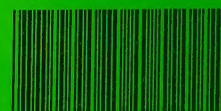








MP MASTER



MA23649